

The Fouling of Mine Casing Surfaces by Fluorescent Organisms

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Grant Number: N00014-98-1-0028

LONG TERM GOALS

Our long term goal is to determine whether the measurement of fluorescence from benthic surfaces improves our ability to detect mine-like objects on the sea floor. Our hypothesis states that the introduction of a new surface, such as a mine casing, into a benthic habitat disrupts the normal succession of species in the habitat. The disruption is manifested as changes in biodiversity and corresponding benthic biooptics which can be remotely sensed by a fluorescence mapping device.

OBJECTIVES

We want to predict the change in species diversity associated with the introduction of a new surface into benthic habitats. We have focused on the species succession of fluorescent organisms which occurs during colonization and the subsequent changes in biooptical properties due to species diversity. We seek to answer fundamental questions concerning the time scales of fouling, degree and rate of disguise for contrast and shape factors compared to the surrounding habitat and pathways of succession for seagrass vs. macroalgal climax communities.

APPROACH

Our original approach was to monitor mine-like objects provided by Dr. Mike Strand of Coastal Systems Station in Panama City, FL. MLO's and companion control surfaces placed in temperate (Boothbay Harbor, ME) and sub-tropical (Key West, FL) benthic habitats were imaged using still and video underwater photography. SCUBA supported sample collections were analyzed for fluorescent spectral signatures and species identification.

The seasonal succession of benthic flora in sub-tropical waters has been previously outlined (see Seagrass Ecosystems, McRoy and Heifferich, 1977). The succession to algal climax communities such as *Thalassia sp.* depends on the substrate (den Hartog, 1973). The suite of species is different for hard, sandy and mud bottoms. Each suite may be composed of diverse species of micro-, macro- and coralline algae. On sandy and muddy substrates, initial recruitment is associated with bivalves. We have outlined the succession for temperate waters where initial recruitment is similar to the sub-

Report Documentation Page				Form Approved OMB No. 0704-0188	
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1. REPORT DATE 30 SEP 1999		2. REPORT TYPE		3. DATES COVERED 00-00-1999 to 00-00-1999	
4. TITLE AND SUBTITLE The Fouling of Mine Casing Surfaces by Fluorescent Organisms				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Bigelow Laboratory for Ocean Sciences,180 McKown Point Road,West Boothbay Harbor,ME,04575				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT Same as Report (SAR)	18. NUMBER OF PAGES 4	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			

tropical scheme, but climax communities do not converge resulting in macroalgal covers on solid substrates and *Zostera marina* (eelgrass) or green macroalgal mats on sediments.

This year, we identified other existing targets to include in our studies to obtain data from different water types, benthic habitats and climax communities. In particular, a derelict minefield off Key West, FL, was researched and relocated with the assistance of Mel Fisher's group, Motivation, Inc., (Bolen, 1999). These targets represented 40+ years of fouling, we hoped that this community would constitute an important, long term data point that would be impossible to obtain through our current efforts.

WORK COMPLETED

The temperate and sub-tropical targets and control surfaces have been followed for nearly two years at regular intervals. We have also monitored four additional targets placed at Lee Stocking Island, Bahamas, after one year of deployment in the clear waters adjacent to Exuma Sound as part of the ONR sponsored CoBOP project. For surveillance of mines that have been submerged over many years, we extended our studies to include a WWII vintage minefield off Key West, FL, in conjunction with the Coastal Systems Station and Raytheon FILLS system. Mines were located by side scan sonar, and one sunken mid-water mine and its concrete mooring were documented by still and video photography with companion measurements of water column optics, pigment concentrations and physical parameters obtained over several days. At night, the area was surveyed using the line scanner system deployed on an active towbody from R/V Sea Diver.

RESULTS

The den Hartog (1973) model for seasonal succession of seagrasses and macroalgae forms a good basis to test the effects of adding a foreign substrate to benthic habitats. We have observed that if a mine casing is placed in a climax community such as *Thalassia* or *Laminaria* (kelp), the surface quickly becomes dominated by turf algae (Figure 1). This is just as the model predicts. In terms of a visual

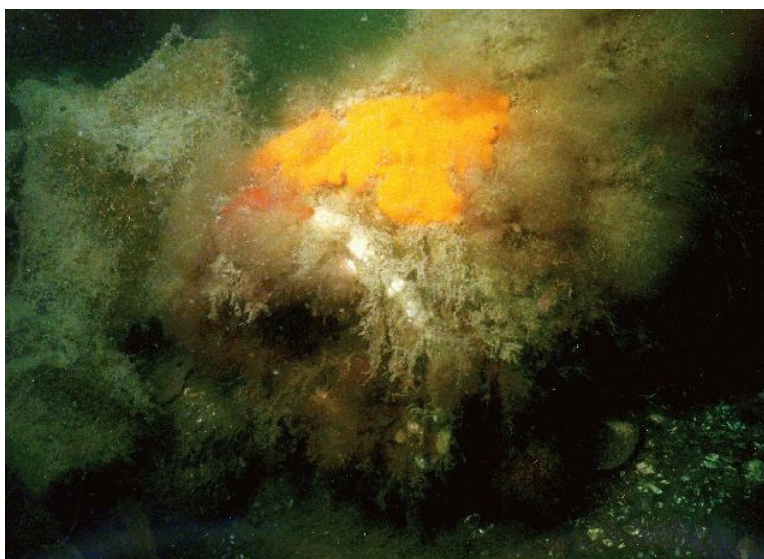


Figure 1. Aft end of 500 lb. projectile casing submerged in Boothbay Harbor, ME. Kelp frond at left, yellow spot is non-fluorescent colonial ascidian, white area is metal edge of casing.

perspective, this does not promote concealment. Rather, the contrast between the turf algae and the surrounding climax community or sediment is improved since the shape is well defined. Highest concealment occurs when the climax canopy overgrows the object covered by turf algae or when the object is placed among other hard substrates. As time passes, the diversity of turf algal species increases and the appearance of small forms with upright thalli create a cover which may improve concealment of the shape on the top and ends (or outer edges). The vertical surfaces require longer to foul, presumably due to shading or settlement differences. Fluorescence spectral signatures from all the major groups of macroalgae (greens, browns and reds) are observed at this time. Non-fluorescent invertebrates also begin to invade the turf community, covering large areas. The yellow crustose mass in Figure 1 is a colonial ascidian, sponges can be seen on the WWII mines as black, lobate masses on the arming port (Figures 2) and on top of the concrete mooring block.



Figure 2. Side view of a mid-water mine casing from derelict Key West minefield, sunk on the bottom for over forty years. Circular feature in center is the arming port, black masses are sponges, white area to right is turf algae covered with marine snow from water column.

Settlement of suspended material from the water column can also act to reduce the fluorescent signal by burying any turf algae. The derelict mid-water mines and moorings were heavily encrusted with a climax community that appeared non-fluorescent to the FILLs sensor when towed at altitudes of 12-15 feet above the target. They were easily imaged by FILLs in the inelastic scattering channel and detected by side scan and front viewing sonar, they presented as a pair of targets with four foot relief on a smooth sand bottom. Similar signatures have been observed for mines in deeper water with less fouling. The inability to resolve fluorescence could have been due to the high water column attenuation of the excitation and emission fluxes. To test this, we placed a set of fluorescent panels on the bottom next to the targets and observed weak fluorescence in all channels of the FILLs sensor.

IMPACT/APPLICATIONS

This study combines aspects of ecological succession theory with a practical application for prediction of the rate of bio-fouling on mines. Ecological models such as the den Hartog (1973) model are still only qualitative (Phillips and Menez, 1988). We believe we can formulate a remote sensing scheme (passive and active) which can serve as a guideline for mapping resources or as a military tool. The

nature of succession in marine communities favors a transition from pioneering to climax species which is mirrored by increased albedo, decreased pigment diversity and, perhaps, decreased bulk fluorescence. All of these can be useful as diagnostic indicators of fouled man-made objects and for assessing temporal and spatial changes in benthic resources.

TRANSITIONS

The knowledge developed in this project has resulted in direct interaction with the FILLS group led by Dr. Mike Strand at the Coastal System Station, Panama City, FL, during joint field efforts off Key West. A workshop is scheduled for February, 2000, in Key West to develop a means for the transition of this information and to determine the overall effectiveness of using fluorescence for mine detection.

RELATED PROJECTS

The work described above by Dr. Mike Strand is Document Number N001499WX30267. The FILLS sensor is used to image targets in monochrome and fluorescence modes, we are responsible for still and video photographic documentation, water column optics, species identification and fluorescence spectral signatures of fouling organisms.

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